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### (54) ADJUSTABLE STRAP

(71) We, DUNLOP LIMITED, a British Company, of Dunlop House, Ryder Street, St. James's, London S.W.1, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

This invention relates to an adjustable strap and in particular, though not exclusively, to a strap suitable for medical applications.

One aspect of eye surgery is concerned with the treatment of detached retina and this requires local depression of the surface of an eyeball. In some cases it is necessary to maintain the depression for a period while healing occurs and in other cases depression may be required permanently. It is therefore necessary to provide compact depression means which is reliable and easy to use and which can be left in close contact with the eyeball and surrounding tissues for long periods without any detrimental reactions.

One technique employed to achieve a local depression is to encircle an eyeball with a strap in the form of a narrow band made from, for example, silicone rubber reinforced with polyester fabric. The band is applied under tension against the natural elasticity of the eyeball and this results in a general circumferential distortion of the eyeball. A local depression is then created by introducing a pad of, for example, silicone rubber between the band and eyeball at the position where the depression is required.

Since the band must pass beneath the muscles attached to the eyeball a closed loop band cannot be employed. The band is therefore inserted beneath the muscles as an open-ended strip and subsequently joined into a closed loop form by stitching. In practice difficulty is experienced in performing the stitching operation such that the resulting band is of the appropriate length to

exert the required forces against the eyeball and an alternative strap or method avoiding an in situ stitching operation is desirable.

A further disadvantage of the aforescribed technique is that adjustment of the band length either at the time of an initial operation or at subsequent stages of treatment requires the band to be restitched.

The desirability of providing an easily adjustable strap also occurs in fields other than medical. For example in the guy ropes for tents or the rigging of a boat it is desired readily and quickly to adjust the effective length of a rope, often by shortening or lengthening the length of a closed loop at the end of the rope or by moving the joint between two rope lengths. Other applications arise in the field of packaging where strap-like elements such as strings, ropes, cords and ribbons are utilised whether or not in closed loop form.

One object of the present invention is to provide an improved strap readily adjustable in length without the need for stitching.

According to one aspect of the present invention an adjustable length strap comprises a first end portion of tubular shape and having an opening in the wall thereof to permit a second end portion of the strap to be passed through said wall and received in the first end portion, the tubular end portion being of a braided construction extensible in the direction of the length of the strap to contract onto the second end portion in gripping contact therewith and compressible in said direction to expand and permit relative movement of the first and second end portions to facilitate adjustment of the effective length of the strap.

The strap may comprise a single length of material which forms a closed loop when the two ends are brought into contact, or it may comprise two or more lengths and an interconnecting member with one pair of ends of said lengths for bringing into gripping con-

tact and another pair of ends being spaced apart by the intermediate member.

The strap may be tubular along a substantial part of its length, and to facilitate drawing of the second end portion through the braided tubular portion by a pulling movement it is preferred that a pair of openings are provided in the wall of the tubular portion, spaced apart in the direction of the length of the strap, for the passing of the second end portion therethrough.

The second end portion for gripping by the braided tubular end portion is preferably substantially solid and/or incompressible in a direction perpendicular to the length of said portion so as to be readily grippable by the said braided portion without requiring the braided portion to undergo as substantial a reduction in cross-sectional area as would be necessary if the said portion were, for example, of deformable tubular form.

Instead of being solid the second end portion may be tubular and have a solid core, such as a rod of silicone rubber, positioned therein to render said second end portion substantially incompressible for gripping contact by the braided first end portion.

In straps of the kind where the end portions are interconnected at least in part by an intermediate portion of braided tubular construction, said intermediate portion may be provided with a substantially solid core. The core may be a continuation of that referred to in the preceding paragraph. The core may be elastic in the direction of its length by virtue of the properties of the material from which it is formed, e.g. silicone rubber, or it may be substantially inelastic either by virtue of the core material per se or any reinforcement component embedded therein.

In accordance with a further aspect of the present invention said tubular shaped first end portion has located therein a threading needle to one end of which the second end portion of the strap may be attached and thereby drawn through the tubular portion simultaneous with removal of the needle therefrom.

The threading needle may be rigid but preferably is substantially flexible so as to be relatively easily manoeverable within the confined space around an eyeball and eye muscles and thereby permit it to be readily withdrawn from the tubular shaped portion.

In a preferred embodiment the threading needle is formed from a length of braid which may be similar to that forming the first and/or second end portion of the adjustable strap, and the braid may be coated with silicone rubber or other suitable material such that one end of the needle is inherently hollow and substantially bell-mouthed in shape. Subsequently the second end portion of the strap may be located in the bell-

mouthed portion of the needle in gripping contact therewith to facilitate its drawing through the tubular portion simultaneous with removal of the needle from the tubular portion.

In an alternative embodiment, however, the threading needle may be formed in the region of one end with an eye or other means to facilitate attachment thereto of the second end portion of the strap.

Depending on the desired size of strap and tension capacity, either textile type materials or metallic materials such as wire may be used for forming the braided tubular portion and any other parts of the strap.

Two embodiments of the invention will now be described, by way of example, with reference to the accompanying drawings in which:—

Figure 1 shows part of a strap in accordance with the present invention;

Figure 2 shows the use of the strap of Figure 1 to cause circumferential compression of an eyeball, and

Figure 3 shows part of another strap in accordance with the present invention.

In accordance with a first embodiment of the present invention a strap 10 for use in circumferentially compressing an eyeball is formed from a single length tubular sleeve of tightly braided terylene yarn woven to a diameter in the order of 2 to 3 mm.

One end portion of the sleeve constitutes an outer link 11 for receiving therein an inner link 12 at the other end portion of the sleeve such that reduction in cross-sectional area of the outer link causes it to grip against the inner link.

Entry and exit holes 13, 14 for the passage of the braid through itself are formed at diametrically opposite points a few millimetres apart near to that end of the sleeve at that portion forming the outer link 11. The holes 13, 14 are formed by displacing rather than severing the braided yarns so as not to weaken the strength of the sleeve.

That end of the sleeve forming the inner link 12 is constructed with a needle 15 which facilitates insertion of the inner link through the holes 13, 14 in the outer link. The needle is formed by unravelling the braid of the second end portion, tapering off the thickness of the resulting bundle of unravelled yarns by selectively cutting back individual yarns, impregnating unravelled yarns in an epoxy resin, and moulding to a tapered point. Subsequent polishing provides a smooth surfaced needle integral with the braided sleeve and of similar lateral dimensions to those of the sleeve.

To preserve a substantially circular cross-sectional shape to that part of the sleeve forming the inner link a silicone rubber rod (not shown) is located in the sleeve and extends longitudinally over the adjustment

range of the inner link.

In use of the device as a strap which is to be tightened around an eyeball, the needle 15 of the inner link 12 is threaded respectively through the holes 13, 14 in the outer link 11. Tightening is then effected by pulling on the needle 15 whilst gripping the other end of the sleeve on that side of the hole 14 opposite hole 13. During this operation the braid of the outer link 11 between the holes 13, 14 is in a relaxed condition to allow sliding of the needle 15 and the inner link 12 therethrough. When the desired tension has been achieved in the strap the ends are locked together by pulling on the tab portion 16 of the outer link end, this being the portion of the sleeve on that side of hole 13 opposite the hole 14. The pulling action causes locking by contracting the braided structure of the outer link onto the inner link, and if any further adjustment in tension or position of locking is required it will be appreciated that this can readily be achieved by selectively compressing and stretching the braided sleeve between the holes 13, 14.

Subsequent to tightening a small silicone rubber pad 17 (see Figure 2) is then inserted beneath the strap to create a localised depression in the required position on the eyeball.

When the strap is adjusted to the desired final position or tension the resin-reinforced needle and any surplus braid may be cut off and fraying of cut ends prevented by fusing of the terylene fibres with a cauterising instrument.

In accordance with a second embodiment of the invention a strap 20 for use in circumferentially compressing an eyeball is formed from a single length tubular sleeve of tightly braided terylene yarn woven to a diameter of the order of 2—3 mm.

One end portion of the sleeve constitutes a tubular shaped outer link 21 for receiving therein an inner link 22 at the other end portion of the sleeve such that reduction in cross-sectional area of the outer link causes it to grip against the inner link.

Entry and exit holes 23, 24 for the passage of the braid through itself are formed at diametrically opposite points a few millimetres apart near to the end of the sleeve at that portion forming the outer link 21. The holes 23, 24 are formed by displacing rather than severing the braided yarns so as not to weaken the strength of the sleeve.

The tubular outer link 21 is provided therein with a threading needle 25 which is formed from a length of braid of substantially similar construction to that of the tubular sleeve forming the strap 20. The needle 25 has a first end portion 26 extending beyond the outermost hole 23 of the tubular outer link 21, and a second end portion 27 extending beyond the inner hole 24 of the tubular outer link 21. The first end portion 26

is impregnated with vulcanised silicone rubber for a distance approximately 5 mm from the end of the needle and is shaped to define a substantially bell-mouthed hollow opening.

The end 28 of the inner link 22 is stiffened either by means of resin or a short metal pin inserted therein and subsequent to positioning of the adjustable strap around an eyeball the end 28 is located in the bell-mouthed opening of the threading needle so as to be in frictional engagement therewith. If necessary the braid of the bell-mouthed opening may be extended axially to assist in providing a good grip with the end 28 of the inner link 22. The second end portion 27 of the threading needle is then pulled away from the tubular outer link 21 so as to draw the needle out of the outer link and simultaneously thread the inner link 22 through the outer link 21. Subsequent to adjustment of the strap to the required length and tension the tubular outer link 21 is extended axially to close down into gripping contact with the inner link 22 and retain the strap at the required length in the same manner as described above in respect of the first two embodiments of the invention.

The provision of a threading needle located in the tubular outer link 21 prior to use of the adjustable strap serves to maintain the circular configuration of the holes 23, 24 and thus assist in the passage therethrough of the inner link 22. There may therefore be used a more slackly woven braided structure for the tubular outer link than would otherwise be acceptable if the tubular outer link were to be required to be substantially self-supporting. By virtue of the slacker weave of the braid there may be achieved a better grip on the inner link 22.

In a modification of the described embodiments the portion of tubular braid interconnecting the first and second end portions, i.e. the inner and outer links, may be provided with a core element of silicone rubber formed integral with the substantially solid inner link and extending within the tubular braid to a position close to the outer link (e.g. near position 14 in Figure 1 and position 24 in Figure 3).

In use of a strap of this kind, tensioning of the strap will cause the braid to drawn down firmly onto the core and the elasticity of the band will then be related to the elasticity of the core material. The core may alternatively contain an embedded reinforcement, such as a strand of polyester fibre which renders the core substantially inelastic. Accordingly, in this case, in use of the strap the braid will initially extend slightly as it is drawn down onto the core but further extension will be resisted by the core and the strap will then be substantially inextensible.

From the foregoing it will be appreciated that especially in comparison with a strap

that requires stitching in order to effect a joint a strap in accordance with the present invention is simple to adjust to the desired setting both at the time of initial application and subsequently. Furthermore the strap joint is very compact and since the strap can readily be constructed from materials such as terylene and silicone rubber any problems which might arise due to reaction and non-compatibility with human tissue when used for medical applications are avoided.

#### WHAT WE CLAIM IS:—

1. An adjustable length strap comprising a first end portion of tubular shape and having an opening in the wall thereof to permit a second end portion of the strap to be passed through said wall and received in the first end portion, the tubular first end portion being of a braided construction extensible in the direction of the length of the strap to contract onto the second end portion in gripping contact therewith and compressible in said direction to expand and permit relative movement of the first and second end portions to facilitate adjustment of the effective length of the strap.
2. An adjustable length strap according to claim 1 wherein only the first end portion is of tubular shape.
3. An adjustable length strap according to claim 1 or claim 2 wherein the second end portion is substantially solid and/or incompressible in a direction perpendicular to the length of said portion.
4. An adjustable length strap according to any one of the preceding claims wherein said tubular shaped first end portion has located therein a threading needle to one end of which the second end portion of the strap may be attached and thereby drawn through the tubular portion simultaneous with removal of the needle therefrom.
5. An adjustable length strap according to claim 4 wherein the threading needle is substantially flexible.
6. An adjustable length strap according to claim 4 or claim 5 wherein the threading needle is formed from a length of braid similar to that of the tubular shaped first end portion.
7. An adjustable length strap according to claim 6 wherein one end of the threading needle is substantially bell-mouthed in shape.
8. An adjustable length strap according to any one of claims 4 to 6 wherein the threading needle is provided with an eye to facilitate attachment thereto on the second end portion of the strap.
9. An adjustable length strap according to any one of the preceding claims wherein the first and second end portions are portions of a single length of material.
10. An adjustable length strap according

to any one of claims 1 to 8 wherein the first and second end portions are spaced by an intermediate member.

11. An adjustable length strap according to any one of the preceding claims wherein the first and second end portions are interconnected by a tubular intermediate portion having a core element located therein.

12. An adjustable length strap according to claim 11 wherein the core element is formed of a substantially elastic material.

13. An adjustable length strap according to claim 11 or claim 12 wherein the core element has provided therein a substantially inextensible reinforcement extending in the direction of the length of the core element.

14. An adjustable length strap constructed and arranged substantially as hereinbefore described with reference to and as illustrated in Figures 1 and 2 of the accompanying drawings.

15. An adjustable length strap constructed and arranged substantially as hereinbefore described with reference to and as illustrated in Figure 3 of the accompanying drawings.

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COMPLETE SPECIFICATION

1 SHEET

*This drawing is a reproduction of  
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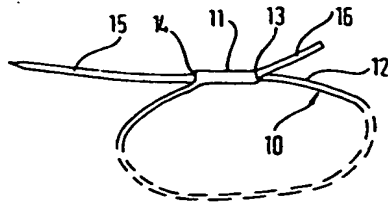


FIG. 1

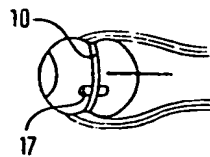


FIG. 2

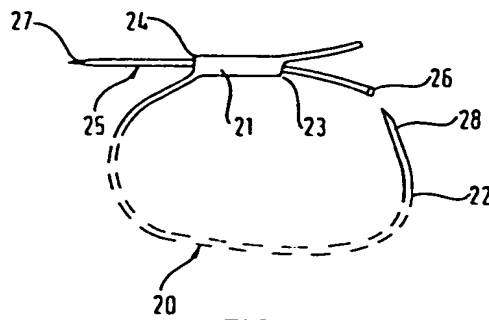


FIG. 3

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